

Site-Specific Nutrient Management

For Nutrient Management Planning To Improve Crop Production, Environmental Quality, and Economic Return

Presentation Script: Micronutrient - Chapter 7

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... and justice for all

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Micronutrient Management

Slide 1.

This module will cover the principal concepts of micronutrient management in agricultural systems to provide for profitable crop production. The presentation will not go through specific scenarios for all regions of the U.S., but general concepts regarding micronutrient management will be presented. Even though these principles apply for most regions, as suggested for other nutrients, viewers are encouraged to review locally developed recommendations for these nutrients.

Slide 2.

Micronutrients are those essential elements required in very small quantities for plant growth and reproduction. The quantity needed varies with each plant species and with each specific element. Seven essential elements are considered micronutrients, and include boron, copper, chlorine, iron, manganese, molybdenum, and zinc. These nutrients are absorbed by plants in the form shown in brackets. To better understand the relative amounts needed by plants, we can look at the crop removal rate. For example, harvest of a 150 bu/acre corn grain crop will remove approximately 135 pounds of N, 23 pounds of phosphorus and 33 pounds of potassium per acre. In comparison to these macronutrients, the removal amount for the micronutrients boron, copper, iron, manganese and molybdenum, and zinc are only 0.06, 0.06, 0.10, 0.09, 0.03 and 0.15 pound per acre, respectively. Even though the needed micronutrient amounts are small, without them plants would not grow and reproduce.

Slide 3.

Traditionally, the main sources of micronutrients for crop growth have been those naturally present in soil and amounts added as impurities in fertilizers and pesticides. Specific soil and related crop situations, however, can result in deficiency of one or more micronutrients and potentially serious limitation to crop production. An example is iron deficiency chlorosis in soybean, which coincides with soils having alkaline pH and free carbonates. In some areas, micronutrient deficiencies have been diagnosed frequently and producers are taking a closer look at the general availability of these elements. For high yields and positive economic return to crop production, it is important to correctly recognize and correct micronutrient deficiencies. If micronutrients become a limiting factor, other inputs such as seed, water, and fertilizer are less

efficiently utilized and may be wasted. There are some important organic compounds called chelates, that help maintain solubility of micronutrients such as Fe, Zn, Cu, and Mn when applied to soils and therefore increase plant availability.

Slide 4.

The total amount of micronutrients absorbed by plants is typically quite small compared to macro and secondary nutrients. This table lists the amount of each micronutrient, except chloride, taken up by several crops.

Slide 5.

A brief description of the importance of each micronutrient is presented in the following slides, along with the situations in which micronutrient deficiencies are more likely to occur and a general description of fertilization practices. A primary function of boron is related to cell wall formation, so boron deficient plants may have stunted growth. Since boron is not readily translocated from older to actively growing tissues, when deficiency occurs the terminal bud can stop growing and will die if the deficiency persists. Sugar transport in plants, flower retention, pollen formation, and germination are also affected by boron deficiency. Boron deficiency symptoms first appear at the growing points. This results in a stunted or bushy appearance near the top of the plant, yellowing of newer leaves, barren ears due to poor pollination, hollow stems and fruit, and brittle, discolored leaves and loss of fruiting bodies.

Slide 6.

Boron deficiencies are found mainly in sandy soils, in regions of highly weathered soils, low soil organic matter, exposed subsoil, and pH above 7.0. Organic matter contains much of the boron in soils. Boron is present in the soil solution mainly as the undissociated boric acid form or the ionized form at high pH values. These are the predominant boron forms taken up by plants. Plant available boron forms are somewhat mobile in soil and can be leached from the root zone, but they move less than other anions like nitrate or chloride. Sorption by clays and association with organic matter helps retain boron in soils and provides sources of available boron for crops. Boron deficiencies are more pronounced during drought periods when root activity is restricted in the upper profile where available boron is typically higher. Boron fertilizer application can correct deficiencies, but the application rate, method and crop should be carefully considered because toxicity can easily occur. Band application in the seed furrow generally is not recommended because high boron concentration can be toxic to seedlings and also can result in

injury to developing plants. Crops more sensitive to boron deficiency include alfalfa, canola, and sugar beet. Many crops are sensitive to boron toxicity.

Slide 7.

Copper is a component of enzymes that play a key role in photosynthesis, respiration, lignin synthesis, and carbohydrate and nitrogen metabolism. Copper deficiency results in stunting growth of plants, and since copper is required for lignin synthesis, deficiency affects cell wall strength and prevention of wilting. Copper deficiency symptoms include reduced nodulation and nitrogen fixation in legumes, delayed flowering and maturity; pollen sterility; dieback of leaf tips, stems, and twigs; yellowing of leaves; stunted growth; and pale green leaves that wither easily.

Slide 8.

Copper deficiencies are mainly found on organic soils, sandy soils, and soil with pH above 7.5. Copper uptake decreases as soil pH increases. Plants roots take up copper as the copper ion. Copper uptake by plants can be reduced by excessive phosphorus and iron availability. Cool and wet conditions favor copper deficiency. Crops more sensitive to copper deficiency include corn, wheat, and oat. Broadcast application of copper mixed with other fertilizers is a common application method. Since the conversion of Cu to unavailable forms is slow in most soils, an application can correct deficiencies for several years with the exception being very sandy soils. However, repeated application should be monitored closely for total copper application. Further application should be discontinued when suggested maximum rates have been applied. Because of potential toxicity, if copper is applied in bands, sprayed to foliage, or from a chelated material, the application rates should be lower than with broadcast applications.

Slide 9.

Iron is involved in the production of chlorophyll in plants; therefore, iron deficiency, called iron chlorosis, is easily recognized on sensitive crops by yellowing of leaves due to low levels of chlorophyll. Iron also is a component of many enzymes associated with energy transfer, nitrogen reduction and fixation, and lignin formation. Iron is associated with sulfur-containing compounds that catalyze several other reactions. Leaf yellowing first appears on the younger upper leaves in interveinal tissues. Severe iron deficiencies cause leaves to turn completely yellow or almost white, and then brown and tattered as leaf tissues die.

Slide 10.

Iron deficiencies are found mainly in crops grown in sandy soils, in organic soils and in high pH soils, usually above pH 7.2 and with free carbonates which reduces iron solubility. Cool, wet soil conditions enhance iron deficiency, especially in soils with marginal levels of available iron. Poorly aerated or compacted soils also reduce iron uptake by plants. Uptake of iron is adversely affected by very high levels of available phosphorus, manganese, and zinc in soils; and in soybean iron chlorosis is aggravated by high concentrations of soil nitrate. Development of iron chlorosis is quite variable due to the many soil, climatic, and plant interactions related to deficiency. Plants roots take up iron as the ferrous and ferric ions, and as a component of organic complexes of low molecular weight. Plant species vary significantly in their sensitivity to low iron supply. Sensitive crops include soybean and grain sorghum. Due to soil interaction that greatly reduces iron solubility and plant availability, foliar or planter-band applications often are the most effective iron fertilization methods. Research has shown that variety selection is typically a more effective solution than iron fertilization.

Slide 11.

Manganese is involved in enzyme activation for plant photosynthesis, nitrogen metabolism, and synthesis of various compounds. Interveinal chlorosis is a characteristic manganese deficiency symptom in many plants, and has similar appearance as iron deficiency chlorosis. In severe deficiency situations, brown necrotic spots appear on leaves and premature leaf drop occurs. Delayed maturity is another deficiency symptom in some species. White or gray spots on leaves of some cereal crops are signs of manganese deficiency, such as “grey speck” in oat due to tissue breakdown.

Slide 12.

Manganese deficiencies mainly occur on organic soils with pH above 5.8, high pH mineral soils with free carbonates, soils with poor drainage and high organic matter levels, saturated conditions with poor aeration, sandy soils, and over-limed soils having low cation exchange capacity. Crops sensitive to manganese deficiency include soybean, oat and wheat.

Due to interaction with soil that greatly reduces manganese solubility and plant availability, foliar or band applications often are the most effective manganese fertilization method. A common foliar treatment is application of manganese sulfate; however use of chelates is becoming more common. Use of a chelated manganese fertilizer for foliar or band application allows for lower application rates compared with broadcast application. In marginally deficient

soils, banding acid forming fertilizers with the planter can prevent or alleviate manganese deficiency by solubilizing soil manganese compounds.

Slide 13.

Molybdenum is involved in enzyme systems related to symbiotic nitrogen fixation in legumes, nitrogen and sulfur metabolism, and protein synthesis. Molybdenum has a significant effect on pollen formation, so fruit and grain formation are affected in molybdenum deficient plants. Because molybdenum requirements are very low, most plant species do not exhibit molybdenum deficiency. Deficiency symptoms in legumes mimic nitrogen deficiency because of the primary role of molybdenum in nitrogen fixation. Unlike most other micronutrients, molybdenum deficiency symptoms are not confined to the youngest leaves because molybdenum is mobile in plants. The characteristic molybdenum deficiency symptom in some crops is irregular leaf blade formation known as whiptail, but interveinal mottling and marginal chlorosis of older leaves also have been observed.

Slide 14.

Molybdenum deficiencies are found mainly on very acid, highly weathered, sandy soils in humid regions. Molybdenum availability and uptake by plants increases with increasing soil pH, which is the opposite of other micronutrients. Liming acidic soils is the most practical and cost-effective way of correcting molybdenum deficiency and acidity problems at the same time. However, if fertilization is needed, a low molybdenum rate usually is applied as a seed treatment or planter banded along with other fertilizers.

Slide 15.

Zinc is an essential component of enzymes important for energy production, carbohydrate metabolism, protein synthesis, and growth regulation. Zinc is not mobile in plants, so zinc deficiency symptoms occur mainly in new growth early in the season. The most visible zinc deficiency symptoms are short internodes, a decrease in leaf size, and a broad band of bleached tissue that goes across leaf veins.

Slide 16.

Zinc deficiencies are mainly found on sandy soils low in organic matter, eroded soils with exposed high pH subsoil greater than 7.3, severe root growth restrictions, and organic soils. Crops sensitive to zinc deficiency include corn, grain sorghum, and soybean. Zinc deficiencies occur more often during cold, wet spring weather, which is related to reduced root growth and

activity as well as less microbial activity and thus less zinc release from soil organic matter. Uptake of zinc can also be adversely affected by application of high phosphorus fertilizer rates when soil zinc availability is marginal. Application to the soil is a common method of applying zinc fertilizers. There are many zinc fertilizers available, with choice depending on the intended application method, rate desired, and solubility of the fertilizer. Zinc oxide is the least soluble form and must be finely ground for enhanced availability. Zinc sulfate, oxysulfate, and zinc-ammonia complex are inorganic sources that provide varying degrees of available zinc. Zinc chelates enhance availability due to lower zinc ion interaction with the soil. In marginally deficient soils, banding acid forming fertilizers with the planter can prevent or alleviate zinc deficiency in high-pH soil by solubilizing soil zinc compounds.

Slide 17.

The chloride elemental form is not found in soils or plants, instead it is present as the chloride ion. Plants take up the chloride ion. Because chloride is a mobile anion within plants, most of its functions relate to osmotic effects, like stomatal opening and electrical charge balance in several physiological functions. Wilting and restricted, highly branched root systems are the main chloride deficiency symptoms, which are found mainly in cereal crops. The role of chloride in decreasing the incidence of various diseases in small grains is perhaps more important than its nutritional role.

Slide 18.

Most soils contain sufficient levels of chloride for adequate plant nutrition. However, chloride deficiencies have been reported on sandy soils in humid regions or soils derived from low chloride containing parent materials. Crops sensitive to chloride deficiency include wheat, potato, and barley, but a few crops, tobacco, for example, are very sensitive to high chloride levels. There are few regions with chloride deficiency, mainly because chloride is applied to soils with potassium chloride, the predominantly used potassium fertilizer. However, in regions with naturally high available soil potassium, no chloride containing potassium fertilizer is normally applied so chloride deficiency is more common.

Slide 19.

Soil tests aid in determining whether a particular nutrient is responsible for poor crop production and provides the basis for deciding the type and amount of fertilizer needed to correct a nutrient deficiency. Soil samples collected for laboratory analysis must consist of a number of cores and a

number of samples from the field. Care is needed to avoid contamination from sampling tools, sample containers, and other micronutrient sources. Various soil extractants are calibrated for use in different geographic areas and can extract widely different amounts of micronutrients.

Therefore, for proper interpretation of test results, one must use the test calibrated for a particular region, soil, nutrient, and crop. The reliability of most micronutrient soil tests, compared to other tests like phosphorus and potassium for example, is in general lower. Also, some soils with low micronutrient levels in the surface layer may not respond to fertilization because they have higher available levels of the nutrient in the subsoil. Therefore, confirmation of a deficiency with trial nutrient application, tissue testing, and visual symptoms is helpful to confirm deficiency.

Slide 20.

Plant tissue tests can aid in determining if a particular nutrient is responsible for poor crop growth. When a deficiency is detected by tissue testing, a reduction in yield due to restricted crop growth has likely already occurred. As with soil analysis, plant tissue tests must be calibrated with field fertilization trials. Calibration of tissue tests is far more complex than for soil tests because measured nutrient concentrations vary considerably with the stage of plant development and the portion of the plant sampled. Special care is required in taking plant tissue samples, including soil contamination. Tissue test interpretation should be based on calibrations with yield response for specific crops, plant part sampled, and stage of plant growth. An appropriate number of samples should be collected to appropriately represent the field area of interest. Fresh samples should be taken quickly to a lab or air-dried to remove excess moisture before they are shipped to a lab. Collecting soil and plant tissue samples at the same time can aid in determining if a micronutrient is deficient.

Slide 21.

Micronutrient fertilizers are applied to the soil or foliage. Foliar or planter-band applications often are more effective than broadcast applications to the soil because the nutrient is applied directly to the foliage or for some micronutrients, except for chloride, banding minimizes reactions of soluble forms with the soil that reduces crop availability. The decision regarding whether to use a foliar or soil application, and associated product, will depend on the nutrient, crop production system, potential soil interaction, and cost of material and application. In addition, because toxicity can occur easily for some micronutrients, such as boron, the fertilizer form, placement, and rate should be carefully considered and based on reliable local research

information. Table 2 lists some of the more common micronutrient fertilizers and analyses.

There are four main categories of micronutrient fertilizers: inorganic, synthetic chelates, natural organic complexes, and fritted glass. Common inorganic fertilizers include oxides, sulfates, and oxysulfates.

Slide 22.

Due to the low plant nutrient requirement, crop specificity for deficiency, and the soil/climate/nutrient interaction, for many crops and geographic regions - practical experience with micronutrient deficiencies is often the best system for determining the need for micronutrient application. Diagnosing and correcting micronutrient deficiencies can be complicated. For example, reliability issues associated with soil and plant tissue testing for micronutrients in some regions, like the Midwest; the large variety of conditions that affect micronutrient supply; and the large variety of fertilizer sources. For these reasons, the following steps are suggested for identifying and correcting micronutrient deficiencies. Ensure that poor crop growth in a field or portion of a field is not the result of a macronutrient or secondary nutrient deficiency, compaction, excess moisture, drought, salinity, pest problem, or herbicide injury. Find out if a micronutrient deficiency has been identified before in a particular crop or soil type in the area. Examine the affected crop for known specific micronutrient deficiency symptoms. Take separate soil and plant tissue samples from affected and unaffected areas for complete analysis, and analyze samples for other nutrients and soil pH in additions to micronutrients.

Slide 23.

If most indications point to a micronutrient deficiency, apply the micronutrient to a specific, clearly marked, affected area in order to observe results and compare with non-treated areas. In choosing a micronutrient fertilizer, consider the solubility, safety concerning damage to seedlings or foliage, advantages and disadvantages for foliar or soil application such as potential for interaction with soil, and cost. If a micronutrient fertilizer is applied with the seed, in bands, sprayed onto foliage, or from a chelated material, the application rates typically would be lower than with broadcast or non-chelated material applications. Consider that other crop inputs such as pesticides, lime, or manure can supply micronutrients or may affect the availability of micronutrients present in the soil. For example, liming acid soils is a very cost effective way of increasing crop availability of molybdenum, but excess lime application to soil that is slightly

acid to neutral pH, or liming alkaline soils, can decrease the availability of other micronutrients such as copper, iron, manganese, and zinc.